Notes on the *Chernetidæ*, with special Reference to the Vestigial Stigmata and to a new form of Trachea. By HENRY M. BERNARD, M.A. (Cantab.). (From the Huxley Research Laboratory, Royal College of Science, London.) (Communicated by W. PERCY SLADEN, Sec. Linn. Soc.)

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(PLATES XXXI. & XXXII.)

IN a short paper* containing additional evidence as to the origin of tracheæ from setiparous sacs, I stated that I had discovered an *Obisium* which, in addition to the ordinary two pairs of stigmata on the second and third abdominal segments, had also seven pairs of rudimentary, or rather vestigial, stigmata on the seven remaining abdominal segments.

The specimen on which these vestigial markings were first found was brought from the Thüringer Wald, and was macerated in boiling caustic potash (figs. 1 & 1 *a*, *v.s.*). I am now indebted to Dr. Günther, F.R.S., for kindly placing at my disposal six alcohol specimens from bottles labelled "*Obisium museorum*" and "*O. sylvaticum* or *carcinoides*." Of these, four were cut into serial sections; one, owing to some extraordinary hardness in the abdomen, resisted all efforts to cut it, the razor bending and sliding over it; the remaining specimen was boiled in caustic potash.

No trace of these vestigial stigmata could be found in the sections, but in the macerated specimen (labelled *O. sylvaticum*, figs. 2 & 2 *a*) they were immediately found, though differing in position from those on the Thüringer specimen. The object of this paper is to describe the results of my investigation of these interesting markings. At the same time, a brief description of certain new points which have come to light in the course of this investigation can hardly fail to be of interest. Since Menge (6), there has been only one paper (by Croneberg (2)) dealing specially with the anatomy of the Chernetidæ, although observations on single points have been recorded.

The outer form of the Chernetidæ requires no description. The chief point of importance morphologically is the relation of the basal regions of the cheliceræ to those of the pedipalps. The Chernetidæ agree with *Galeodes*, the Araneidæ, and, so far

* Ann. & Mag. Nat. Hist., Jan. 1893.

as I can ascertain, with *Schizonotus*, in having the basal parts of the pedipalps directly under, or ventrally to, the basal regions of the mandibles, which form the "cephalic lobes" *.

In this ventral position of the basal regions of the pedipalps, the Chernetidæ are more primitive than *Scorpio*, in which the same parts have been forced up laterally by the crowding forward of the legs towards the anterior end of the body. The result of the arrangement in the Chernetidæ is curious: owing to the enormous size of the pedipalps, and the consequent development of their muscles, nearly half the ventral surface of the cephalothorax is taken up by the coxal joints of these limbs (fig. 2). The four leg-bearing segments, which are fused together at least ventrally, are entirely confined to the posterior half of the cephalothorax.

Although there is no waist or diaphragm as in so many other Arachnids, there are very deep lateral infoldings of the skin between the sixth and seventh segments (figs. 2 & 12, *i.*). And further, the ventral segmental constriction between the sixth and seventh segments is very deep, which would allow the abdomen to be raised. These may be the first beginnings of a waist.

The Chernetidæ agree with *Galeodes* in possessing a rostrum or beak, which consists essentially of two parts, a dorsal "labrum" and a ventral "labium" †. The former is flattened laterally; its tip is thin-skinned, and in "*Obisium museorum*" curiously divided in the median line, so that in horizontal sections it looks as if it were produced into two horns (fig. 5); this part is probably sensory. The mouth is on the ventral surface, and closed by the wedge-shaped labium which fits into the oral aperture as shown in the transverse section (fig. 4). This pointed labium is apparently quite rigid, and reminds us of the remarkable process between the pedipalps of *Phrynus*, which may be a homologous structure. Further, in *Scorpio*, short as the labium is, it is of essentially the same shape when examined in serial sections.

In *Galeodes*, the mouth is at the tip of the rostrum. In the

* My use of this term is explained in a short note on the "Head of *Galeodes* and the procephalic lobes of Arachnidan embryos," in the 'Zoologischer Anzeiger,' no. 426, 1893.

† I use these terms to indicate the homologies which I think are the most natural. I cannot see what is gained by endeavouring to deduce the rostrum from fused limbs (Croneberg (3)).

position of the mouth, the Chernetidæ come midway between *Galeodes* and *Scorpio*. The interesting homologies of these mouth-parts I propose to discuss fully in a paper on the Galeodidæ which is now in preparation.

On the inner anterior edges of the basal joints of the pedipalps there is a pair of movable lamellate processes (fig. 5), which, from the strength of their muscles, clearly serve to hold prey in front of the mouth, and perhaps to squeeze the juices out of soft bodies. The homologous processes in nearly the same position in *Galeodes*, *Phrynus*, and *Thelyphonus* are quite immovable, and appear to be sensory. In the Mygalidæ and Scorpionidæ they are still clearly traceable, but apparently much degenerated.

The endosternite in the Chernetidæ is especially interesting, and affords additional evidence of the apodematous origin of this structure, so patent in the Galeodidæ. The endosternite in these animals owes its origin to apodemes formerly present between the leg-bearing segments which are now completely fused together. We accordingly find it situated far back in the cephalothorax. It is now simply a small firm centre from which muscles radiate to the four pairs of legs and to the genital operculum (fig. 11).

The Muscular System.

The muscular system of *Chernes* is comparatively simple. It is essentially of the same type as that of the Araneids. The chief differences found in the musculature of Arachnids depend upon the mobility of the coxæ. In *Galeodes*, in which the coxæ are fixed, all the muscles which in the Araneids move these joints are either wanting or are modified for other functions. In the Chernetidæ the coxæ are movable, but not to the same extent as in the Araneids. We consequently have a system of muscles arising from the lateral and dorso-lateral regions of the cephalothorax for the rotation and raising of the coxæ. As a rule, the muscle which rotates and moves the coxa one way crosses that which rotates it in the contrary direction. In addition to these rotating muscles which, when acting together, must lift the coxa, the muscles from the endosternite apparently also serve as elevators. I could find no body-muscles attached to the trochanter. All the leg-muscles proper are confined to the coxal and other joints.

The upper lip is provided with remarkable transverse muscles, found also in the upper lip of *Scorpio* and of the Araneids (fig. 4). The under lip is raised by a pair of muscles descending on each side from the dorso-lateral sclerite of the basal joint of the pedipalp.

The muscles of the mandibles are, as is the case in all the Arachnida, confined entirely to the "cephalic lobes," *i. e.* to the region which in other Arachnids corresponds with the lobes forming the so-called head of *Galeodes* *.

Powerful muscles run from the sides and back of the cephalothorax into the abdomen, serving to raise the latter, and perhaps also to move it from side to side.

There are seven pairs of dorso-ventral muscles in the abdomen, commencing in the first abdominal segment. These muscle-bands, which slope downward and outward, are attached dorsally to the tergites on each side of the dorsal vessel or dorsal blood-sinus, and ventrally to the sternites. They cause regular constrictions of the lateral diverticula of the alimentary canal (fig. 6).

The abdominal papillæ, through which the glands formerly thought to be the spinning-glands open, appear as if they could be raised and depressed, *i. e.* by raising the chitinous folds from which they are differentiated (fig. 10). The muscles marked m_1 in the figure appear to be elevators, those marked m_2 depressors (found only for the posterior papilla).

Histologically, the muscles are like all Arachnidan muscles; each fibre consists of a medullary axis of sarcoplasm with transversely striated bands arranged radially around it as a cortical layer.

The Alimentary Canal.

The alimentary canal offers many points of special interest. Its general form has been already rightly described and figured by Croneberg.

Inside the mouth, the passage is both dorsally and ventrally finely striated transversely, as in the Araneidæ. On leaving the beak, the œsophagus suddenly swells into a sucking apparatus, which has already been accurately described by MacLeod (5), although I agree with Croneberg in disputing the rudimentary condition of the organ. The dorsal expanding muscles are attached to an apodeme between the mandibles and the pedipalps,

* *Cf.* note on p. 411.

which extends backward in the median line to form an arch over the sucking apparatus, and is an extension backward of the dorsal surface of the labrum. The lateral expanding muscles are attached to the outer sides of the coxal joints of the pedipalps. In *Galeodes* this sucking apparatus is not so specialized, and the œsophagus can be expanded and contracted almost along the whole beak. *Obisium*, therefore, in the formation of its mouth-parts, comes halfway between *Galeodes* and the Scorpion, which latter has no freely projecting beak, but has a small specialized sucking apparatus in the same position as in *Obisium*.

On leaving the sucking apparatus, the œsophagus again narrows to pass through the central ganglionic mass, widening again at once into a great system of diverticula which fill the whole body (fig. 6). There seem to be two pairs of primary diverticula. The first pair must be subject to fluctuations in size, as they sometimes reach to the dorsal surface, and at others lie beneath the massive coils of the spinning-glands (fig. 9), which, as we shall see, are very differently developed at different times. This first pair fills all the space in the cephalothorax not occupied by other tissues. It must be considered as the equivalent of the four pairs which typically belong to the four posterior cephalothoracic segments in Arachnids. The fusion of the four leg-bearing segments above described will account for the fusion of the four pairs of originally separate diverticula. In *Scorpio* the four pairs of diverticula have also fused to form one pair, this being due to the longitudinal compression of the whole cephalothorax.

The second pair is the more important. Its two branches run laterally the whole way down the dorsal surface of the abdomen, sending down secondary diverticula laterally and ventrally. These secondary diverticula are due to the constrictions caused by the six posterior pairs of dorso-ventral muscles (fig. 6). The muscular passages thus formed between the secondary diverticula will be referred to again. About the same place where these two diverticula diverge, there is a median ventral primary diverticulum. A similar median ventral diverticulum has been described by Schimkievitch * and Bertkau † in the Spiders.

* "L'Anatomie de l'Epéire," Ann. d. Sciences Nat., Zool. xvii. (1884).

† "Ueber den Bau und Function der sog. Leber bei den Spinnen," Arch. f. Mikr. Anat. 23 Bd. (1884).

A short distance after the divergence of these three diverticula the main trunk of the canal suddenly narrows to form what may, perhaps, be the hind-gut. This forms a loop, running backward to nearly the end of the body, bending forward again and then backward. Just before the anal aperture, it widens to form a kind of stercoral pocket, which is, however, by no means so specialized as are the homologous structures in *Galeodes* and the Araneids. The anus is *apparently* a transverse slit, but in reality it is a median slit hidden in a transverse fold in the cuticle.

The epithelium of this intestinal tract shows but slight differentiations. From the proximal end of the œsophagus to the commencement of the "hind-gut," the cells are absolutely alike; there is apparently no division of labour; each cell performs all the functions of digestion, like an independent unicellular organism. In *Obisium* the cells are large and lobate, stretching out far into the lumen. The food absorbed by them is transformed into homogeneous globules which look exactly like oil-drops. These are so numerous that the nucleus is completely obscured. There is occasionally a peripheral layer of granular protoplasm, traces of which may also be found between the food-globules.

On close examination these food-globules are found to become granular, and ultimately to break down into a number of minute crystal-like bodies. These latter are regularly excreted between the cells and cast out in a stream, apparently in some slimy substance, into the lumen of the gut, to mix freely with the undigested food. Where the alimentary canal suddenly narrows to form the hind-gut, these "crystals" are separated from the food, and from this point they alone are to be found, which accounts for Menge's statement that fæcal formation commences at this point, whereas, as a matter of fact, it is at this point that the fæcal matter is separated from the other contents of the canal.

I have not hesitated to call these crystalline bodies fæcal, as it seemed clear to me that they were the undigested remains of the food-globules in the individual cells; they are found, apparently unchanged, as by far the most important if not the only constituent of the fæcal masses in the stercoral pocket. There can therefore be very little doubt that they are the irreducible remains of ingested food.

While examining these small refractive granules I was strongly reminded of the similar crystalline bodies found in Amœbæ. On referring the matter to my friend Mr. Moore, he informed me that he had himself come to the conclusion that the so-called "crystals" of Amœbæ are the indigestible remains of food-globules, which in these animals also are almost indistinguishable from oil-drops. Mr. Moore's conclusions were already in print*, otherwise this complete and unexpected confirmation of them would no doubt have been mentioned.

In one specimen, infected with bacteria, these large digesting cells, while apparently retaining their purely digestive functions, seem to be unable to get rid of the excreted matter which accumulates between the cells, as shown in fig. 8.

These simple conditions of the digestive processes in *Obisium* are of great importance. They have enabled us to recognize the supposed secretions of the "liver" cells of the Arachnids as no true secretions, but as homogeneous food-globules, and the various forms of "crystals" found in the cells as the fæcal remains of these food-globules. It follows, therefore, that the whole subject of the digestion of the Arachnids, so ably worked out by Plateau † and Bertkau ‡ from the old point of view, should be restated from the new point of view above described, that the cells lining the diverticula of the alimentary canal are not glandular cells filled with their secretions, but digesting cells whose contents are to be referred to food in various stages of digestion. I have endeavoured to follow up this subject in a paper read before the Royal Microscopical Society and since published in that Society's Journal (Aug. 1893).

Outside the basement-membrane of the digesting epithelium is a layer of single cells homologous with the "fat body," described by Bertkau as occurring between the "hepatic" diverticula of the Araneids. These peritoneal cells vary considerably in shape, in some places being almost tile-shaped, and in others long and cylindrical. This latter form is sometimes found when these cells form part of the boundary of a blood-sinus, where they are free to develop. In places, on the other hand, where they are liable to be squeezed between adjacent parts of the

* Ann. & Mag. N. H., Feb. 1893.

† "Recherches sur la structure de l'appareil digestif et sur les phénomènes de la digestion chez les Aranéides dipneumones," Bulletin de l'Acad. Royale de Bruxelles, 2e Série, tom. 44 (1877).

‡ *L. c.* p. 414.

gut, they are vacuolated to such an extent as to form a sponge-like connective tissue, the large nuclei being suspended on the threads. The boundaries of the individual cells, however, can still be made out. Without such an arrangement as this, there could be very little free movement of fluids within a body so completely filled up by mid-gut diverticula. The bacteria in the pathological specimen alluded to on the preceding page seem to form nests in these cells (fig. 8).

Just as the undifferentiated epithelium immediately round the opening of the œsophagus suddenly changes into the large digesting cells above described, so with like abruptness, when the intestine narrows to form the hind-gut, do these cells change into an epithelium of short thick cells with very large nuclei. These line the whole of the portion which I have called the hind-gut, as far, that is, as the enlargement answering to the stercoral pocket of other Arachnids. In the uppermost and last coil of the loop these show signs of being highly amœboid and vacuolated (fig. 7). Here and there the whole lumen of the tube is found to be filled with two or three cells distended by immense vacuoles, the nucleus being visible simply as a large body suspended in a fine membrane.

Croneberg found no Malpighian tubules in *Chernes Hahnii*, and I have entirely failed to find any trace of them in *Obisium*. The apparent entire absence of these organs in the Chernetidæ is somewhat remarkable, as these tubules are enormously developed in *Gibbocellum* according to Stecker's description and figures (8). The Chernetidæ, on the other hand, are not ill-provided with glands, as we shall see below. We shall perhaps obtain some insight into the physiological significance of this absence of Malpighian vessels in these animals when we have a tabulated survey of those glands which in the Arachnids serve to remove waste products from the body. I propose to draw up such a list of the glands in the Arachnids in a more comprehensive work dealing with the comparative morphology of the Galeodidæ.

The Circulatory System.

On account of the minuteness of the heart and the limited supply of material at my disposal, I have been unable to throw much light on the disputed question as to the number of ostia. Winckler discovered only one terminal pair; Croneberg finds three pairs, and Daday four pairs in the cylindrical part of the dorsal vessel, and, in addition, four extra openings in a rosette-like terminal portion.

In a series of transverse sections, I found that in the dorsal median line above the hind-gut (*cf.* figs. 6 and 7) there existed a blood-sinus full of coagulum, but without any trace of a dorsal vessel. The heart or dorsal vessel commenced (working from behind forward) where the hind-gut joined the mid-gut. I should therefore be inclined to think that there could be only one pair of ostia in the abdomen. Whether there are any in the cephalothorax I was unable to ascertain.

A cross section of the expanded heart might almost be mistaken for that of *Scorpio*. There is even a pair of fibrous bundles attached to the ventral surface, and drawing down the pericardium into the long conical processes which we find in *Scorpio*, the muscular attachments of which have been called by Lankester * the veno-pericardial muscles.

The blood collected by the heart from the median dorsal sinus and the pericardium is driven forward through the coils of the spinning-glands; after circulating in the anterior regions of the body, it returns along the ventral surface, finding its way to the heart again through the constrictions (*m.d.*, figs. 6 and 8) of the diverticula formed by the dorso-ventral muscles and in the median plane between the mid-gut diverticula, bathing the hind-gut on its way into the median dorsal sinus.

In the pathological specimen (p. 416), the globular nests of bacteria are found chiefly in the walls of the passages formed by the dorso-ventral muscles which were enormously stretched by coagulated blood (fig. 8).

Glands.

The spinning-glands were always supposed to be near the genital aperture, where also, according to Stecker, they occur in the related (?) form *Gibbocellum*. The important discovery by Croneberg, that they are really in the cephalothorax and emerge behind the tip of the movable joint of the mandibles, I have been able fully to confirm. At the same time, the view of the older zoologists was not altogether wrong; there are glands which

* Lankester and Beck, Trans. Zool. Soc. vol. xi. pt. 10.

occur near the genital aperture, which might very easily be mistaken for spinning-glands. To these we shall return.

The fine chitinous ducts of the true spinning-glands open, in *Obisium*, on a blunt prominence at the back of the movable digits of the mandibles; they can be seen running down these limbs, about seven in number, and not more than 1 μ in diameter (see fig. 2 *a*, *d*). These seven or more ducts lead into as many somewhat coiled cylindrical reservoirs (6 μ in diameter), which again gradually pass into the secreting portions of the glands. These, the glands themselves, run more or less straight backward immediately under the dorsal wall of the body, sometimes reaching into the second or third abdominal segment. The cells composing the wall were so packed with granules that I entirely failed to discover any nuclei. In glands which appear to be degenerating, the granules were fewer and the cells seemed to be breaking down. In these cases a fine staining-reticulum can be seen running among the granules; this and the trace of staining round the periphery of the gland are the only signs of protoplasmic arrangement I could perceive, besides the fine radially arranged lines bounding the separate cells. These glands are accompanied by a number of exquisitely fine tracheal tubules. The homology between these spinning-glands and the poison-glands of the Araneids is obvious. I do not think that the absence of the very specialized muscle-layers in the latter is a point of importance.

These glands seem to be subject to periodical variations; Croneberg found them most fully developed in summer. One of my specimens shows no other trace of them than their chitinous ducts in the mandibles.

The extremely thin and transparent combs on the mandibles, said to be used as manipulators of the silk, are formed by folds of the external hard refractive layer of the chitinous cuticle.

The abdominal glands open by median papillæ. The anterior papilla projects from the anterior edge of the second segment, and opens under the genital operculum. The posterior papilla is similarly situated at the anterior edge of the third segment, and is covered by the segmental fold of the second segment. *Gibbocellum* has spinning-glands on the second abdominal segment, and Stecker suggests their existence on the third segment also.

Stecker describes the glands in *Gibbocellum* as opening through a number of minute papillæ, in which case they would probably be true silk-glands. It is worth recording, however, that the same kind of openings have been claimed for these abdominal glands in the Chernetidæ.

The anterior papilla opens into a short duct, into which, laterally and dorsally, groups of large pyriform glands pour their secretions. These glands are so crowded together that the secreting epithelium can properly develop only at their proximal ends, where the cavity is very deep, the cells in section being polygonal owing to mutual pressure (fig. 11).

The posterior papilla leads into a tuberous gland, the exact nature of which it is not easy to make out. The epithelium is like that of the pyriform glands, but the lumen looks like a shrunken chitinous sac (figs. 10, 11, 12).

These glands were developed only in one of the specimens at my disposal (figs. 10, 11). In the other three specimens, traces of them were visible in one; in a second the part was unfortunately torn away from the sections; while in the third there was no trace of them whatever. Evidently, therefore, these glands are, like the true spinning-glands, liable to periodic variations. I may further remark that the only specimen which shows these abdominal glands is the specimen which shows no trace of the true spinning-glands. It is true that my sections are here somewhat broken, but I do not doubt that this is the case. If so, we have here an interesting relation between the spinning-glands and the abdominal glands.

The presence of true spinning-glands on the mandibles, with their manipulating combs, seems to indicate that these abdominal glands are not the producers of the silk for the nest, though the secretion itself in these latter may be somewhat of the same nature as in the former; the largeness of the single apertures shows that they have nothing to do with the spinning of silk. On the other hand, the opening of the more important of the abdominal glands under the genital operculum would imply some connection with reproduction. Croneberg calls them "Kittdrüsen" (cement-glands). The function of these cement-glands is perhaps that of sticking the eggs to the abdominal surface of the mother, as there are several notices in literature that these animals carry about the eggs firmly attached to the ventral surface of the anterior abdominal segments. If this is the case, then it appears as if the male shared with the female the discharge of this function, because from the occurrence of the "ram's-horns," presently to be noticed, the specimen shown in fig. 11 ought, according to Menge, to be a male. According to Croneberg, the abdominal glands are developed both in the males and the females, though presenting slight differences in the two sexes.

The coxal glands are blind tubes with the characteristic walls. The ground-substance of the wall often stains very badly, and appears to be perforated by branching pores, which give the whole a spongy appearance. It is doubtful, however, whether this is the true account of its structure. Nuclei are found in the wall, as shown in fig. 13. The epithelium round the commencement of the tube is very little differentiated. The aperture, which Sturany * failed altogether to find, is on the posterior face of the coxa of the third leg; the Chernetidæ corresponding in this respect with *Scorpio* †. The gland runs inward and forward, whereas in *Scorpio* the gland runs from the aperture inward and backward, owing to the shifting forward of the limbs.

The duct of the gland is coiled, but the coil it makes is not very complicated. Fig. 14 is a reconstruction of the gland from a series of camera-lucida drawings. The blind end of the tube is practically enveloped by the coil. The whole gland is separated from the alimentary canal by the peritoneal cells, which we have already described as investing the whole of the mid- and hind-guts.

The Tracheæ.

The tracheæ open through long slit-like stigmata, from the inner end of which the trunk slopes inward and forward; both the aperture and the trunk are protected by forked hairs projecting into the cavity. It is not easy to see whether these slit-like stigmata are open furrows, or closed tubes, with an opening only at their inner ends (Croneberg). An examination of the specimen shown in fig. 1, where the cuticle is folded, seems to show that the former description is the correct one. The proximal end of the trunk is somewhat widened, and gives rise to an enormous number of fine tubules. These tubules are intra-cellular. Near their points of origin the protoplasm containing

* "Die Coxaldrüsen der Arachnoideen," Arb. Zool. Inst. Wien, t. ix. 1891.

† "The Coxal Glands of *Scorpio*," Ann. & Mag. N. H., July 1893.

the nucleus is seen surrounding them in a thick layer. This protoplasmic investment of the tubules gradually fades away as they spread out through the body until it is no longer demonstrable; indeed, the tubules themselves are so fine that they can be seen only with high powers. The tubules from the anterior pair of tracheæ run forward, from the posterior pair backward, at least in some cases; I could discover no anastomosings or branchings among these tubules.

In addition to these stigmata, there are rudimentary or vestigial stigmata on all the remaining abdominal segments. The claim that stigmata occurred on all the segments was, curiously enough, made so long ago as 1816 by Treviranus *; but, as has been already often pointed out, he mistook the indentation of the cuticle caused by the dorso-ventral muscles for stigmata, and claimed them equally for the dorsal and ventral surfaces. The markings which I claim to be vestigial stigmata are much more definite (figs. 1, 2, and 3); the last figure represents one of the vestigial stigmata (from fig. 2) magnified 2000 times, to show what a definite scar-like mark it is. It appears to be completely closed. That these markings have been overlooked is hardly to be wondered at, as they can be seen only on cleanly macerated specimens with a high (300–500) magnifying power.

There can, I think, be little doubt that these are indeed vestigial stigmata †. Fig. 1 shows how closely in that animal (the *Obisium*, sp., from the Thüringer Wald) they agree, in position and in their relations to the setæ, with the functional stigmata. In fig. 2 we find them in quite another position. This difference in position is exactly what we find in other Arachnids; in some the stigmata are wide apart, as in *Scorpio*; in others (*Galeodes*) they almost, and sometimes even quite, meet in the ventral middle line. This movement of the stigmata is to be attributed to the change of the position of the blood-sinuses owing to the development of the digesting diverticula. When the diverticula develop so as to leave a median ventral blood-sinus, as in *Galeodes*, the stigmata also wander towards the middle line.

* Vermischte Schriften, Bd. i. p. 15, 1816.

† Had there been only two of these rudimentary markings, *i. e.* on the two segments following those which have the functional stigmata, no one would have hesitated for a moment to claim them as the homologues of the third and fourth stigmata of *Scorpio*.

This striking difference in position shown by the vestigial stigmata is rather remarkable, occurring within a well demarcated group such as the Chernetidæ. I would, however, point out that the difference in the number of the abdominal segments claimed for different genera is almost equally surprising. The group is an extremely difficult one to classify; and I am afraid that these vestigial stigmata, visible only on carefully macerated specimens, will not make the task easier, although it is obvious that they are of prime importance for establishing a natural classification of the group.

These nine pairs of stigmata on the abdomen, rudimentary and functional, make it almost certain that the primitive Arachnid had tracheal invaginations on every segment. In the cephalothoracic segments these tracheæ have, as a rule, disappeared, owing to the compression of the six segments which form this region. We have cephalothoracic tracheæ, however, in *Galeodes*, in which the cephalothorax is jointed, and in certain *Acarines* which have failed to develop the abdominal segments. Further, only a certain number of the abdominal tracheæ have persisted; the anterior pairs have become, as a rule, specialized, while the posterior pairs have disappeared.

In addition to these stigmata, functional and vestigial, the remarkable "ram's-horn" organs, described by Menge and again by Croneberg, deserve special attention. It is claimed that these organs are present in the males of all species and genera. I succeeded in finding them only in one specimen, presumably the only male; its actual sex cannot now be determined, as the genital glands have suffered from the attacks of the infesting bacteria above referred to. In this single case, however, these organs present features hitherto unnoticed, which go far to establish Croneberg's belief that they must be homologous with tracheæ.

They are large chitinous tubes, the walls of which are much folded transversely, so that they are capable of considerable extension. I doubt, however, whether this is the object of the folding: it is rather for the sake of flexibility. They open laterally under the genital operculum, which thus protects their orifices. Menge says they are often conical, sometimes ram's-horn-like; they have this latter form in my specimen. From their apertures they rise dorsally, then bend forward, dipping down ventrally in a curve, the whole figure described being somewhat like a ram's-horn (fig. 12). The organs in my specimen are beset with air-chambers closely packed between the muscles and inner organs, wherever, in fact, there has been room for their development.

Croneberg describes these organs as being invested by an epithelium of "small cells ·008 millim. high." I could not find any very clear traces of this epithelium, but the air-chambers appeared to be developed within cells, the nuclei of which could occasionally be seen in a fine layer of protoplasm (fig. 12 *a*).

Menge, who recognized their remarkable likeness to tracheæ, believed these organs to be transmitters of sperm, and says that they are sometimes found turned inside out like the finger of a glove, and protruding from under the genital operculum; and Simon * has a figure in which they are seen hanging out, extending one to the anterior and the other to the posterior end of the body! Whatever this evagination of these tubes may mean, it certainly requires investigation, but in the meantime the mere fact of their opening under the genital operculum in no way necessitates their having any connection with reproduction, as Croneberg seems to think, although he inclines to the belief that they are homologous with tracheæ. The view that they are transmitters of sperm, the latter finding its way into the tips of the tubes which are then evaginated, seems on the face of it so very improbable that it could be accepted only on the most unmistakable evidence.

We have, then, the two views:—(1) The old view that they are reproductive; and (2) the suggestion here made that they are respiratory.

In favour of the first view, we have the following arguments:—

(*a*) They occur under the genital operculum, close to the genital aperture.

(*b*) They have no protective stigmata.

(*c*) They are often found evaginated.

(*d*) They are said to be confined to the males.

In favour of their being respiratory, the following arguments may be used:—

(*a*) Their resemblance to tracheæ.

(*b*) Their position under the genital operculum, *i. e.* in close connection with rudimentary limbs, which is typical of tracheæ.

(*c*) Their occurrence on the 1st abdominal segment is quite

* 'Les Arachnides de France,' vol. viii. 1879, p. 3, pl. xvii. fig. 4.

in keeping with the view that at one time there were tracheal invaginations in every segment.

(*d*) Their position enables them to dispense with protective stigmata. The operculum forms an effective covering for them as well as for the genital opening.

(*e*) The air-chambers, described and figured in this paper, render the respiratory function of the invagination, in this case at least, almost unquestionable.

These five arguments, I think, completely justify Croneberg in homologizing these organs with tracheæ. Further, in addition to these arguments in favour of their being tracheæ, we have the following arguments against their being connected with reproduction :—

(*f*) The entire absence of muscles renders it very improbable that they are transmitters of sperm.

(*g*) I could find no such close connection between their apertures and the median genital aperture as to warrant my thinking that sperm, on being discharged from the latter, would find its way up into these tubes.

(*h*) The only reproductive organs which it seems probable that they might be would be receptacula seminis, but they are said to be confined to the males.

Summing up these arguments, I think the balance of the evidence is in favour of their being tracheæ, and if their claim to serve as accessory reproductive organs is not altogether without foundation, yet, in the case described and figured in this paper, the function of the organs is clearly and exclusively respiratory; I say "exclusively" because respiration is a somewhat exclusive function, at least it certainly would not admit of the air-passages being choked up with sperm-cells.

It seems to me that we may here have to do with one of the simplest of all known tracheal invaginations,—a short blind chitinous tube, without highly specialized crenulations, and without specialized apparatus for the protection of the orifice. Some such chitinous invagination must have been the original starting-point of all the more specialized forms, the lung-books, tracheal tufts, and tracheæ. Further, the formation of the chambers, which appear to be chitin-lined spaces within the original secreting cells, seems to show how the different specializations of tracheæ arose. By the flattening of such chambers one against another, the lung-books could easily be obtained; by the development of each chamber into a long intracellular tubule, the tracheal tuft; and by the development of one or two chambers into long tubes, the tubular tracheæ.

I therefore offer the suggestion that these ram's-horn invaginations opening under the genital operculum, in the Chernetidæ, may be the nearest approach to the primitive form of trachea yet discovered.

In the matter of tracheæ, then, the Chernetidæ are very important Arachnids, and throw a strong light on the origin of the whole group from some earlier ancestor, with a pair of limbs and a pair of tracheal invaginations on every trunk-segment. In the Chernetidæ all trace of the cephalothoracic tracheæ have vanished, unless we can homologize the coxal glands with tracheæ. But on the abdomen the first segment has occasionally a very primitive form of trachea, the two following segments have normal tuft-tracheæ, and the seven following segments seven pairs of vestigial stigmata!

The Sensory Organs.

The structure of the eyes, of which there are in *Obisium* two pairs, may be seen from the diagram (fig. 15). The lenses were not very compact, the layers of chitin showing, in section, a loose lamination which, if not due to the action of alcohol, must detract from their dioptric efficiency. The retinal cells were very large and seemed to be continued into rods, the distal ends of which were embedded in the pigment-cells forming the cup. I could not find out the connection between the nerve and these inverted retinal cells.

The cells secreting the lens form a very distinct layer, the vitreous body. This fact is interesting because the lateral eyes of *Scorpio*, which are apparently the homologues (or ? analogues) of these lateral eyes of *Obisium*, are said to have no such vitreous layer *. This seems to show how very little value can be attached to the structure of eyes in questions of affinity.

Perhaps almost as important as the eyes are the sensory organs found in the arthrodial membranes between the thick chitinous ring at the edge of the coxa and the trochanter on the last two pairs of legs. The fine cuticle seems to project as a

* Lankester and Bourne, "The Minute Structure of the Lateral and the Central Eyes of *Scorpio* and *Limulus*," Q. J. M. S. xxiii.

papilla or as papillæ, into which run at least two very large sensory cells (fig. 16). In addition to these cells, and near them, are found large ganglia composed of some twenty to thirty cells; their connections I was, however, unable to follow. These ganglia were very conspicuous in all four coxæ of the last two pairs of legs, but the long sensory cells I succeeded in finding only in one leg. I had not sufficient material to pursue the investigation further. All important sensory organs discovered on the legs of Arachnids are of interest as perhaps throwing light on the origin of the "raquets" of *Galeodes* and the "combs" of *Scorpio*.

Croneberg further describes a tubular sac, which he takes to be a gland opening at the tip of the movable joint of the pincers on the pedipalps. I have not succeeded in finding such a structure, but Croneberg's description reminds one of the invagination at the tip of the pedipalps of *Galeodes*, which is probably olfactory *.

I have made no special observations on the nervous system.

The Genital Glands.

The general form of the female organ is already well known. The chief point of interest, morphologically, is the union of the paired ovaries to form, with the oviducts, the ring characteristic of so many Arachnids. There is no such fusion in *Galeodes*, which is probably in this respect primitive, while, on the other hand, there are many bridgings between the two glands in *Scorpio*, which is thus more specialized in regard to its reproductive system than any other Arachnid, except perhaps some Acarids. As a matter of fact, the genital glands seem to develop wherever they can, filling up the spaces left by the intestinal diverticula. We have a kind of struggle for existence between two organs in the same body, which, however, cannot from the nature of the case be a war of extermination, but rather an effort to attain the relative proportions most advantageous for the race.

My material was, unfortunately, quite insufficient to work out the problems connected with the sexual glands.

The arrangement of the sexual apparatus seemed to be somewhat complicated, although not so complicated as Croneberg

* "On the Terminal Organ of the Pedipalp of *Galeodes*," Ann. & Mag. Nat. Hist., Jan. 1893.

described. He seems to have included the chitinous folds of the genital operculum, which greatly confused the sections, as parts of the sexual apparatus. This accounts for his considering the ram's-horn organs and the abdominal "spinning" glands as being directly connected with the sexual organs, whereas, if the above account is correct, all these are distinct—the ram's-horn organs are tracheæ without a specialized stigmatic opening, and protected by opening under the genital operculum, and the so-called spinning-glands open on median papillæ at the anterior edges of the 2nd and 3rd segments.

In fig. 11, sections of four out of six (eight?) glands appear, which open into, and overlie dorsally, a chitin-lined pocket, which, if the specimen be really a male, may be a seminal vesicle.

The morphological problems involved in the observations here described will be discussed still more fully in a general work on the morphology of the Arachnida, to be based on an account of the anatomy of *Galeodes*, which is already near completion.

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EXPLANATION OF THE PLATES.

Plate XXXI.

Fig. 1. The ventral abdominal surface of an unclassified *Obisium* (macerated in caustic potash), showing the stigmata on the 2nd and 3rd segments, and a pair of rudimentary stigmata on all the following segments in exactly corresponding positions. On the right, except in the anal and penultimate segments, these rudimentary stigmata are seen through the upper cuticle, the skin being folded. The hairs are not all drawn, but are indicated by their round points of insertion on the cuticle. There are no traces of openings of abdominal "spinning" glands.

Fig. 1 *a*. One of the cheliceræ of the same.

Fig. 2. Macerated specimen from a bottle labelled *Obisium sylvaticum*. The stigmata are seen through the coxa of the last pair of legs. The segmentation at the anterior end of the abdomen is very difficult to ascertain. The hairs or their points of insertion are given only on the left side. The rudimentary stigmata are seen nearer the median line and nearer the middle of the segment than in fig. 1 (on this point *cf.* text, p. 422). The lateral membrane in this species is quite different from that represented in fig. 1. It is beset with minute papillæ. The openings of the lateral infoldings corresponding with the diaphragm or waist of other Arachnids is seen (*i*) just anteriorly to the trochanter of the last pair of legs.

Fig. 2 *a*. The cheliceræ of the same, showing the fine spinning-ducts (*d*) and their openings.

Fig. 3. One of the rudimentary stigmata from fig. 2 (×2000). The black dots are fine refractive points in the cuticle.

Fig. 4. Section through the rostrum, showing the labrum (*L*) folded down laterally, with the labium (*l*) fitting into it. Transverse muscles similar to those shown in the section occur in the labrum of *Scorpio* and of Araneids.

Fig. 5. The movable lamellæ on the coxa of the pedipalps and the paired (sensory ?) prolongations of the labrum. The form of the labium can also be seen, reminding one of the median process between the pedipalps of *Phrynus*.

Fig. 6. Diagram of the alimentary canal. Commencing at the rostrum *r* it swells into the sucking-apparatus *ss*, passes through the ganglionic mass *b*, to dilate immediately into a system of diverticula, of which 1 and 2 are paired and 3 is median and ventral. *o* represents the ovary (which is shaded), the paired oviducts of which embrace the median ventral diverticulum (3); *md*, muscle dissepiments between the secondary diverticula (*sd*) of the 2nd pair.

Fig. 7. Section through the abdomen; *sd*, secondary diverticulum. The large digesting cells excreting between them streams of crystal-like bodies which look black by transmitted and white by reflected light. These bodies are seen mixing with the contents of the canal. The cells are full of food-globules. *f*. Layer of peritoneal cells, Bertkau's "fat-body." *hg*. The loop of the hind gut suspended in the median plane.

The uppermost coil leads into the stercoral pocket, and its epithelial cells are very irregular owing to their being highly vacuolated. *o.* Ovary.

Fig. 8. Horizontal section from a specimen infected by bacteria. *b.* Nests of the parasite in the peritoneal cells. *md.* Muscle blood-passages as in fig. 6, but much distended with coagulated blood. Between the digesting cells, the crystal-like fæcal bodies (*f*) have accumulated instead of streaming out between the cells. *dv.* Dorso-ventral muscles in section.

Plate XXXII.

Fig. 9. Cross section of the cephalothorax to show the position and importance of the silk-glands (*sg*) which open through the ducts in the mandibles (*d*, fig. 2 *a*). *en.* Endosternite.

Fig. 10. The openings of the abdominal "spinning" or cement-glands at the anterior edges of the 2nd and 3rd abdominal segments; *g.* The space under the genital operculum; m_1 and m_2, muscles for elevating and depressing the papillæ.

Fig. 11. Horizontal section; showing the character of the anterior (s_1) and posterior (s_2) abdominal "spinning" or cement-glands; *e*, their secreting epithelium; t_3, portions of the ram's-horn organ; *c*, coxal glands; *m*, muscles from the endosternite to the 1st pair of legs, showing the position of the endosternite far back in the cephalothorax.

Fig. 12. Ditto, diagrammatic; showing the arrangement of the tracheæ. t_1. The posterior pair bent back by the enormous development of the spinning-glands; t_2, the anterior pair, only short lengths of the intracellular tubules are shown; t_3, the ram's-horn organ opening under the genital operculum (*g*); they are covered in the specimen with air-chambers; *i*, lateral infoldings of the body-wall.

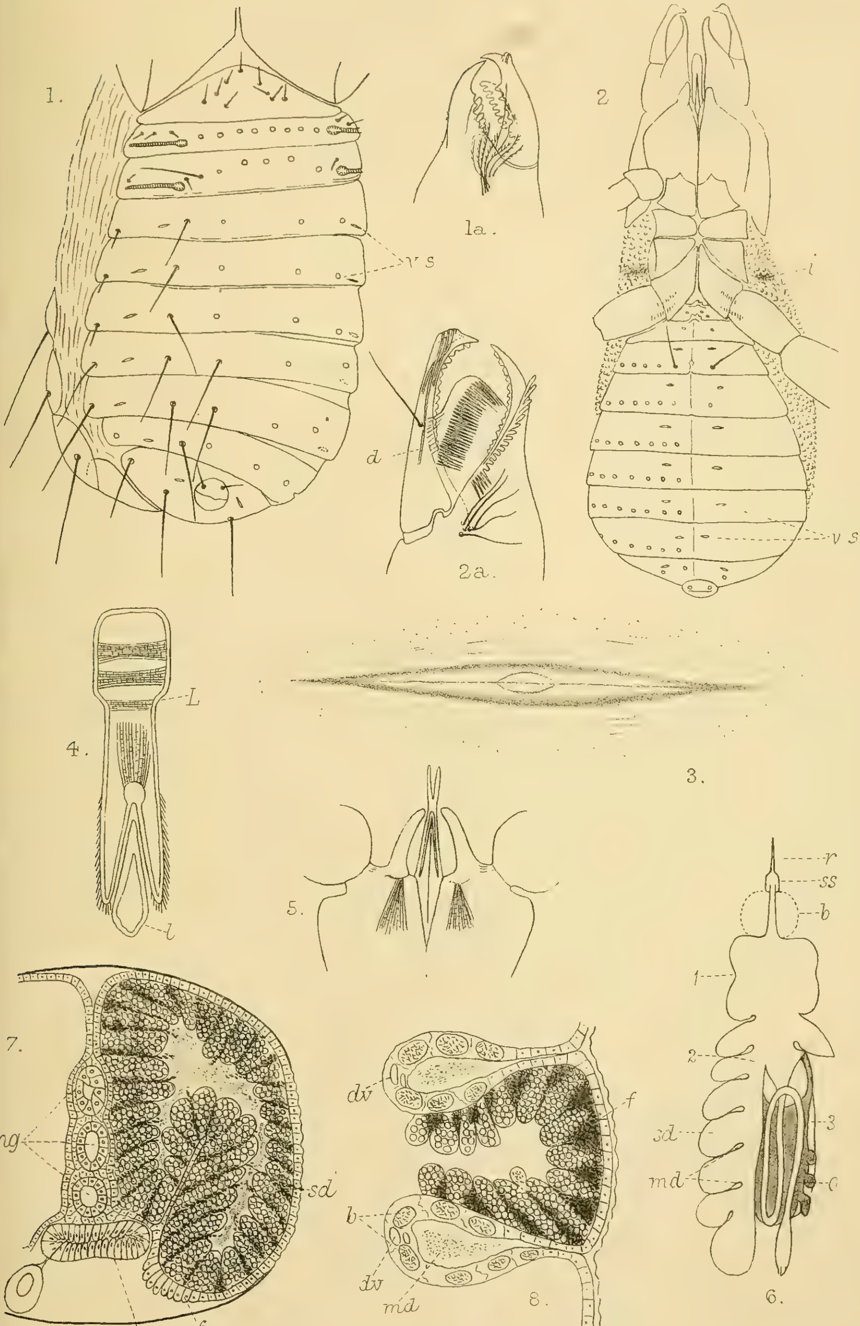
Fig. 12 *a*. Part of the ram's-horn organ with air-chambers, showing traces of protoplasm. The air-chambers are apparently intracellular.

Fig. 13. Cross section of coxal gland, showing the nuclei and the striated appearance of its walls.

Fig. 14. Left-hand coxal gland opening on the posterior face of the coxa of the 3rd leg, reconstructed from sections.

Fig. 15. Section through the eye, the large retinal cells with their distal ends (rods ?) embedded among the cells forming the pigment-cup.

Fig. 16. Sensory cell in coxa of the 3rd leg. *ch.* Section of thick chitinous ring round the distal end of coxa, with secreting hypodermis. The sensory cell runs out into a fold of the arthrodial membrane between the coxa and trochanter.



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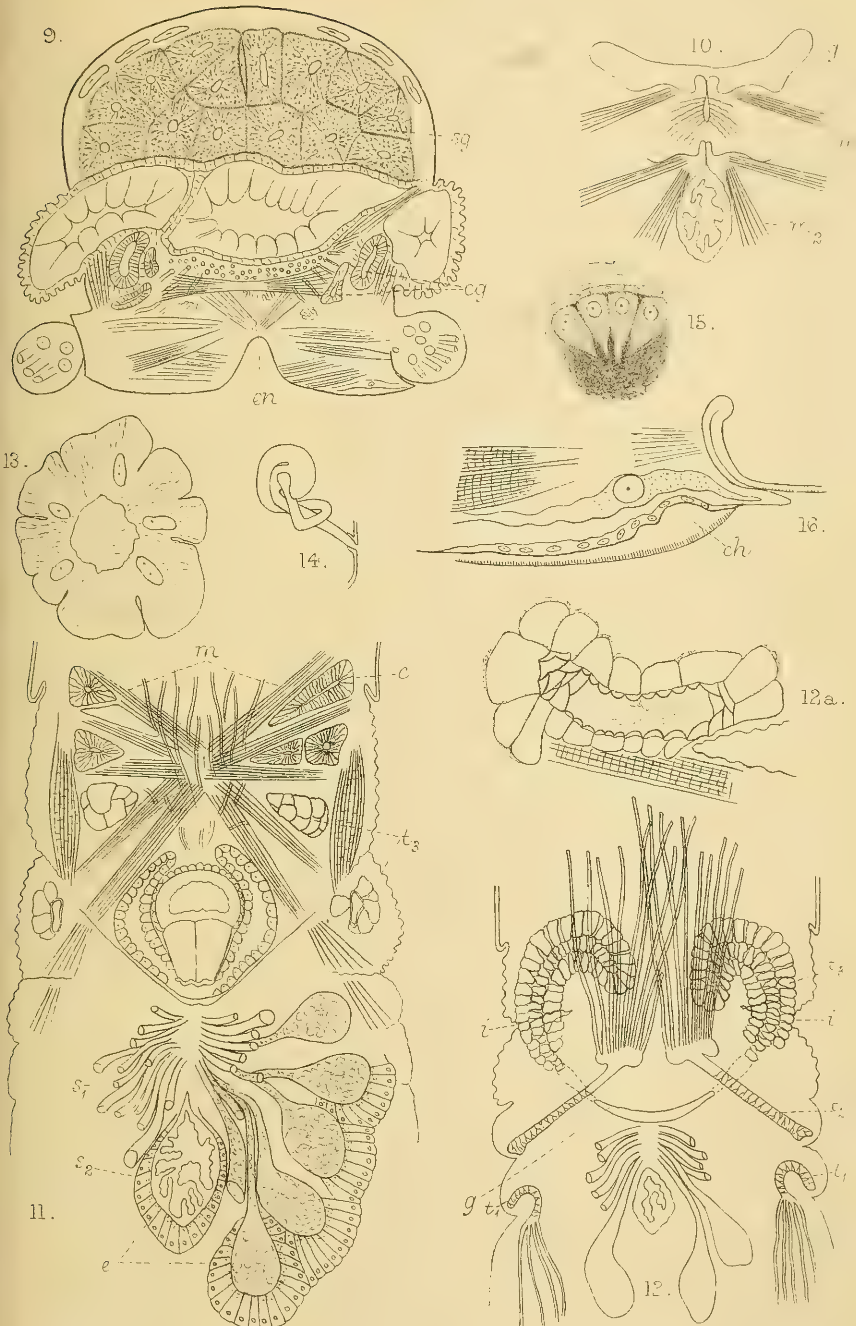

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